

# SIEMENS MICROWAVE NETWORK MANAGEMENT SYSTEMS: EXPERIENCES AND SOLUTIONS

**M.Alberti, M.Bernini, M.Frassetto**

*Siemens Networks S.p.A. - Cassina de' Pecchi (MI), Italy*

**Abstract:** Starting from the birth of NetViewer, the Siemens EMS for microwave radio equipment, a lot of choices were taken and a lot of changes were performed to make the product more effective and powerful, accordingly to the changes of the network scenario in which it operates. The core of the paper concerns the experiences collected during the development of this product, the problems encountered, the solutions applied to face them and the reasons for some choices. Little space is reserved to technical details and theory, only when they give significant clarification about an issue, or when they explain the reason of the choice. *Copyright © Siemens Networks S.p.A. 2007.*

**Keywords:** Management systems, Information Technology, Network topologies, Communication networks, Communication protocols, Telecommunication.

## 1 RADIO NETWORKS EVOLUTION

The rapid expansion of the mobile access networks, occurred in the middle of the nineties and still in progress today, has changed the characteristics of the networks implemented by microwave equipment.

Previously the microwave networks was composed mainly by trunk links, implemented for example by high capacity SDH radio devices. A typical usage of microwave equipment was to complete the fiber-based transport networks, where fiber backbones had to be protected with links based on different technology for security reasons or where fiber was not suitable: e.g. islands to be connected or areas where it was difficult to dig to deploy cables.

In the nineties, this scenario changed: the fixed microwave radio networks started to be used in mobile networks (see Fig. 1). In fact the microwave radio links, mainly PDH, provides a convenient solution to reduce investments for infrastructures for base station interconnections, with respect to wired connection. Reasons for that are the lower cost respect other solutions, short time needed for their deployment and their simplicity in changing or expanding the network structure.

These networks increased more and more and now they are normally composed by a large number of

microwave radio links; on the other hand these devices became cheaper and sometimes simpler, also from the management point of view, than the trunk radio equipment.

This change had a strong impact also on the microwave management systems. Previously the EMSs were designed to be able to manage hundreds of quite complex NEs: for SDH equipment this complexity was due to a complex management protocol (OSI) and a huge information model (CMIP), in addition to the intrinsic complexity of the trunk SDH equipment and their large number of configurations. These EMSs were normally based on UNIX and often were tailored for a given (and generally very expensive) HW configuration.

Anyway, the SDH microwave radio equipment was quite expensive and its EMSs could be expensive too! Finally, it was quite normal to have different management systems for different technologies: the user of a management system was typically an expert of a particular technology and he appreciated complex EMSs able to manage every aspect of the Networks. For these reasons the integrations between different EMSs were possible, but generally not mandatory.

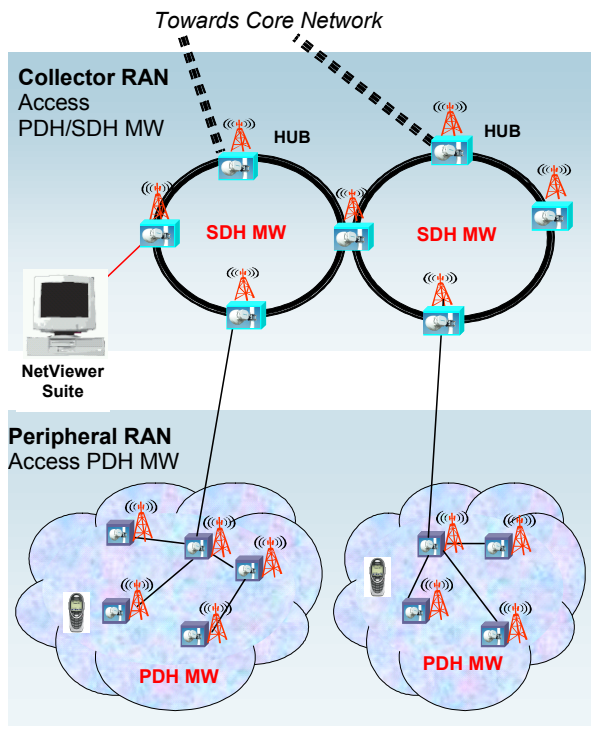


Fig. 1. Microwave radio links usage in mobile networks: a typical scenario.

In the new scenario, the EMSs have to manage thousands of NEs, simpler than the previous ones: the simplicity was due to a simpler management protocol (OSI was abandoned in favor of TCP/IP based protocols) and a simpler information model (i.e. SNMP MIB), in addition to the intrinsic simplicity of PDH 1+0 or 1+1 equipment with respect to the SDH radio trunk radios. These microwave equipment are cheaper than the SDH trunk and also their management system has to be cheaper too! It is mandatory to keep low the cost of the HW, the cost of the operative system and to reduce the time for the system installation and maintenance: in this context Microsoft Windows becomes a valid option as host operative system, and also the possibility to use standard HW becomes a strong advantage.

Referring to the mobile scenario with “simple” NEs, the main target of a microwave management system is to easily and quickly detect the failure of a link (fault management [FM]): in fact, a radio link can be roughly modeled as a “wire in the air” with two states: working and alarmed: considering an integration path of a new equipment in a management system, as a first step performing an effective FM is enough, as normally a mobile operator is mainly focused on the Radio Access Network [RAN] equipment and their management (see Fig. 1). On the other hand, the configuration management of these devices is less important than in the scenario of transport network: the provisioning is usually simpler and seldom, after the first installation, configurations changes are required.

The performance statistics collection becomes important when the network operator wants to

perform preventive maintenance, in order to forecast possible failures, analyzing the trend of equipment performance data. To support the preventive maintenance tools, EMSs are required to be able to collect and store, in an efficient way, a large amount of data, depending on the large number of devices to keep under control.

Also the collection of the physical inventory data is important in this scenario: due to the high number of NEs installed, it is a real advantage to have online the exact situation of equipment on field and their cards in order to properly manage spare parts, swaps, etc.

In this scenario the possibility of the integration of the microwave EMS in the RAN EMS is very appreciated; the RAN EMSs become the entry point for the management of the whole network and in this case the information about the relation between, for example, a BTS and its MW link has to be provided; nevertheless, there are some networks operators who prefer to maintain the RAN and the MW management separated, and where it occurs, normally the responsibility for the different technologies is in charge of different management teams.

In addition to the integration to the RAN EMS, it is often mandatory to integrate an EMS in a set of Operation Systems and Software [OSSs] performing a particular management task for all the network entities (for example: performance management) or in an upper layer Network Management System [NMS]: for this reason the availability in the EMS of standard and easy-to-use northbound interfaces is nowadays mandatory.

Last, but not least, it is not unusual for an equipment manufacturer to resell third party equipment: for this reason the possibility for the EMS to easily integrate equipment not especially designed for it is a real advantage over the competitors.

Finally, it is quite clear that the scenario is very various and complex, so for a manufacturer the availability of a flexible microwave EMS that is adaptable to different situations is a real advantage.

## 2 NETVIEWER EVOLUTION

### 2.1 NetViewer initial stages

NetViewer, the Siemens EMS for microwave radio equipment, appears in the second half of the nineties. The first version of NetViewer was a very simple management product: it was a monolithic SW running on a Wintel PC with low-end operative systems (Windows 95 or NT workstation). It appeared as a simple evolution of the Local Craft Terminal [LCT], with the difference that it was able to connect remotely a few dozens of Network Elements at the same time instead of the co-located one only. In

addition a very limited network view (map view) was supported.

The features implemented were the typical feature of LCTs, i.e. it was possible to focus to a single NE reading its alarms, configuring it completely via the graphical user interface [GUI] and retrieving its measurement data. No database was present; data were stored only in RAM and they were intended to be displayed only in the integrated GUI.

This first release of NetViewer was enough, as a first step, to manage small networks of simple PDH microwave equipment, which were in that time under installation to support the emergent mobile radio networks. But it was not possible to automatically collect and save in a persistent storage the performance data, the alarm records and the events describing what occurred in the network: these limitations became very soon no more acceptable.

It was the beginning of an evolution path which, at the end, would have given to NetViewer the classic functionalities of a management system, with distinctive solutions in same cases.

The following paragraphs briefly describe the actual NetViewer system, focusing on the distinctive solutions and explaining the reasons behind them.

## 2.2 NetViewer architecture

The Siemens Element Management System [EMS] product *NetViewer Suite* provides convenient solution for the problem of NE Operating & Maintenance [O&M].

NetViewer covers the usual management areas for an EMS: Fault, Performance, Configuration and Security Management on the network elements. It is based on client-server architecture. The server is always connected to the NEs in order to collect and save in a persistent storage the information collected from the network. It is logically structured in two layers: a core layer and a modular adaptation layer (described further in the article) to adapt the different management protocol towards the NE.

The NetViewer operators access the system via NetViewer client that connects to the server and displays the requested information in graphical screens. More than one NetViewer GUIs could connect to the same server, so it is possible to have different operators in the same networks at the same time, typically operating with different responsibilities and tasks.

A relational database (currently Microsoft MS SQL Server) is used to make persistent the data collected by NetViewer and to make them available also to other systems.

An upper layer adaptation module can be mounted on the top of NetViewer server to export data to upper layer OSSs and NMSs. This module is described at the end of the article.

*Single server and multi server installation.* The need to manage large networks led to the definition of a server to sub-server hierarchical structure (see Fig. 2). The network can be divided in sub-networks, which contain a part of the entire set of NEs; a main server connects all the sub-servers, and gives a vision of the system as a whole. The operator can manage the entire network connecting to the main server, or only a region connecting to the relative subserver. NetViewer systems can manage small and medium networks up to 2000 NEs, where multi-server installations cover large networks, up to 8600 NEs.

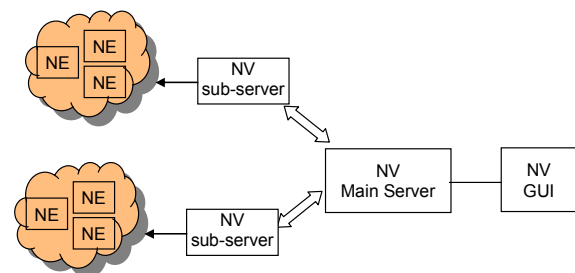


Fig. 2. Main server and sub-server concept in NetViewer.

## 2.3 Platform and update process

The continuous cost decrease of the microwave radio equipment forces the management systems designers keeping low the costs of these products in the same way. This requirement has led to some key choices in NetViewer Suite development:

- The product is based on Windows platform that guarantee low hardware costs, widespread familiarity about its man-machine interface, simple integration and maintenance of other tool based on the same platform: this means low Total Cost of Ownership [TCO].
- There are no fees to pay for included third party libraries or components, because only royalty free open source software is used. On the other hand, this choice allows also using already tested middleware software, avoiding development from scratch.
- The man-machine interaction is based mainly on a graphical user interface and not on a command line interface, so it is simpler to use for an operator, which therefore can be operative in shorter time.

The use of well-known platform for NetViewer deployment gives to the customer the possibility, when there is the need, to customize the installation of the product and sometimes to add to the system some functionalities developed by its own. An

example is the DTS technology, which allows to easily elaborate and process the data extracted from the Microsoft SQL server database: in principle every customer could develop this type of tools according to his needs, as the database schema is public and well documented and the necessary tools are available as part of the database bundle.

The NetViewer hardware and software platforms are subject to a continuous process of technological modernization: the aim is to provide compatibility with the emerging platforms and to achieve the required performance growth. This process is necessary because the size of the managed networks continually increase, together with the amount of data to be processed.

On the other hand, the activities and the development plans, which has the purpose of maintaining our products always at the top of technology, have also some drawbacks. The usage of most recent products and development platforms can take advantages, but also some possible problems:

- some of the involved technologies can be not completely mature (bugs, instabilities);
- need of frequent updates, during development phase, may cause waste of time;
- lack of documentation or use cases;
- possible incompatibility between products or platforms, with the relative solution still not yet provided by the vendors.

All these problems require a constant effort of study to state the right moment for the introduction of a new technology and for the minimization of the possible risks.

#### *2.4 The use of TCP/IP protocol stack*

One of the most important choices in the NetViewer project was the decision to use management protocols based on the TCP/IP protocol stack instead of protocols based on OSI stack. It has been possible because in 1995 we started developing PDH microwave equipment implementing this protocol stack; nowadays it seems quite common for a PDH equipment to implement a TCP based protocol, but in the middle of nineties, when words like “TCP” or “internet” was known only by IT experts, this choice was uncommon and long-sighted.

The choice of TCP stack allowed simplifying the manager implementation, not requiring the implementation of the heavy OSI protocol stack and taking advantage of the fact that the TCP/IP protocol stack was included and ready to be used in the operative systems hosting NetViewer.

#### *2.5 Management protocols: the choice of the applicative layer*

Adherence to standards often is considered as a must, but sometimes proprietary solutions have significant advantages: it is the case of TNMP, the applicative management protocol implemented in SIEMENS microwave equipment. The TNMP (Trivial Network Management Protocol) is similar to SNMP, but it is much simpler and it is convenient when exchanging simple data.

The first application of TNMP (based over TCP) was in a small point-to-point radio device with low processing capabilities, especially if compared to the ones available today; in fact in that context the management protocol simplicity was really a strength. On the contrary, SNMP requires more resources in general and the implementation of (relatively) complex algorithms in order to implement the MIB structure and the related management. In other words, TNMP simplicity allowed having simple agents (in the NEs) and efficient managers supporting high TNMP message rate.

Another difference between SNMP and TNMP is that SNMP is normally based on UDP, while TNMP is based on TCP. The reason of this choice is that TCP is a connection oriented reliable transport protocol assuring that messages are correctly delivered if the connection is active, or that disconnection condition is detected automatically if connection goes down.

As far as in a radio network the DCN is embedded in the radio frame, the automatic detection of a disconnection due to fading is important. Fading can make NEs temporary unreachable and this situation has to be correctly managed to maintain EMS and NEs aligned.

Nevertheless the TNMP protocol has severe limitations in transporting structured objects (e.g. tables) and in exchanging massive data, and this consideration suggested finding alternative solutions as long as equipment were going to support a number of new and more complex O&M features.

When a large amount of data must be transferred, for example in case of NE performance data collection by the EMS, a mechanism based on file transfer is often more suitable; for this reason we adopted the solution to transfer these type of data as a structured XML file transported via FTP.

Another solution to deal with more complex MIB is the use SNMPv2/UDP protocol stack (adopted for example in the Siemens fixed WiMAX BS): the pros are the ease to describe structured data and the diffusion of this protocol; the cons are the complexity in managing the status of “NE unreachable” using UDP that is a non reliable transport protocol.

## 2.6 Plug-in concept in NetViewer

To "plug" in NetViewer new functionalities via optional modules is a key concept in our management system design. The possibility to add a new module implementing a new feature in the existing system, with few changes (or none at all), significantly reduce the effort of developing that new feature and reduce the time to market giving the possibility to react in a short time to the changes coming from the customer.

The plug-in concept in NetViewer is applied at different levels and some examples of the implementation of this approach are detailed below.

*"Plug-in" for NE specific management.* NetViewer has a data-driven engine, which can load additional "plug-in" modules that give to the engine the specific knowledge about the equipment to manage. For each equipment type supported by NetViewer a plug-in must be issued; this plug-in is composed by a set of files of different type for different purposes: for example, there is an XML file describing the alarms of the equipment and their filtering rules, another file describing the data to be displayed in the specific panels related to that equipment type, etc. The plug-in provides also the mapping rules to map the NE specific MIB in the generic NetViewer internal information model.

The NetViewer internal information model can be roughly considered as it was in tabular format, very simple and generic, logically similar to an Excel file composed by a lot of sheets: one sheet for each instance of NE and other sheets containing NetViewer specific information.

The plug-ins are dynamically loaded by the NetViewer engine and can be released separately from it; there's no need to wait a new product release to manage a new equipment type or a new version of equipment: plug-in solution avoids frequent main product release migrations and allows reducing the customer acceptance tests and related costs. Advantages are:

- no wasted time for customers
- fast deployment
- the "core" part of the product is more reliable, because generally does not need changes to add a new plug-in.

*"Plug-in" for protocol adaptation.* Sometimes it is necessary to manage via NetViewer a new equipment type implementing a management protocol not yet supported by the NetViewer engine: in this case the specific NE plug-in is not enough, but a protocol adapter managing the new protocol has to be developed and deployed to the NetViewer system.

This is possible because the NetViewer server component is logically divided in two main layers: the core layer on the top, managing the NetViewer

core common functions, and the adaptation layer in the bottom, that contains the protocol adapter modules (see Fig. 3). Once added the protocol support, a specific NE plug-in is necessary anyway.

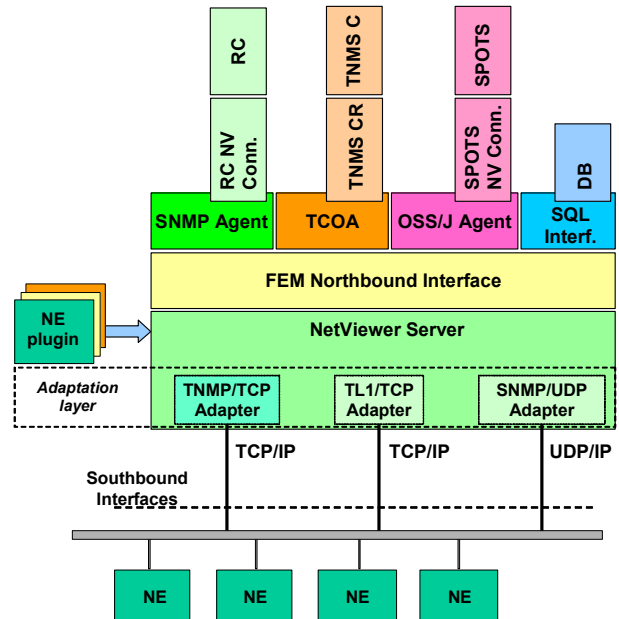


Fig. 3. NetViewer overall architecture.

*"Plug-in" concept for additional modules.* Plug-in concept is applied also to additional modules which can be added to the NetViewer Suite. An example is the addition of optional adaptation modules towards network managers [NMSs] or other OSSs in general; these additional components implement the mapping between NE information base stored in NetViewer and external managers' information base, usually based on data structures and operations defined by standards.

## 2.7 GUI portability and remote GUI launch

The original version of NetViewer GUI was written in C++ for Windows, which prevents from porting it on a different operative system.. A major change has been to develop that GUI in java language, in order to make the interface portable also in non-Windows operating systems, with low effort. The aim was also to simplify the integration of NetViewer in other systems, for example an upper-layer NMS, because the NMS operator could launch the NetViewer GUI in the same O.S. he/she usually works on.

The experience about this point, anyway, revealed that java porting is not a smooth process, because it always requires some work to adapt the product to the new operative system and a lot of tests to guarantee that it really works. On the other hand, the experience taught that a widely accepted solution is the remote GUI launch on the destination operating system, via a commercial remotization tool as, for example, Citrix Metaframe. With the usage of such tools it is not

necessary to retest the graphical interface in other environments than the native one.

## 2.8 A more recent evolution: the functional model

The more recent growing requests of mobile radio services led to the increase of the network complexity: examples are the introduction of traffic protection, ring topologies, etc. This change drove the development of the informative model of the product, from a physical oriented model of the managed radio devices, to a functional centric one. Functional modeling provides enhanced support to service provisioning and makes easier to adhere to standard reference model such as ITU-T and Tele Management Forum series.

NetViewer previous releases provided only a physical modeling (NE, Shelf, Slot and Card). Most recent versions supports a standard TMF MTNM 608 V2.1 information model including Functional component (Termination Point [TP], Cross-Connection and Link). .. ITU-T was discarded because it was too much complicated and somehow “old”, in the sense that TMF MTNM represents its natural evolution. The 3GPP information model was discarded because it has been conceived for the modeling of RAN and UTRAN networks. TMF MTNM / 3GPP adaptation was considered a good solution to place in field when 3GPP is required at Integration Reference Point.

Basing on the functional model, additional modules allow NetViewer to provide a “Network Layer” function. The key functionalities are:

- impact of faults on topological links;
- impact of faults on circuits;
- Logical view of the Network: Connections, Links, Sub network Connections and Termination Points;
- automatic discovery of transport circuits;
- visualization of the Link State between NEs.

Filter capability are available to analyze the interesting aspects of the network circuits (Operational State, Subnetwork Alarm State, and availability of circuit supporting resources).

This recent evolution has been driven also by the introduction, in Siemens MW portfolio, of the WiMAX system, along with Ethernet cards on SDH/PDH equipment. In this modified scenario, still more importance is related to the provisioning issue, for example to configure quality of service to be offered to the end users. The need to configure a end-to-end service has as consequence the need to know and model the entire circuit and all the related objects, and a higher level informative structure is needed in order to be able to manage, in a coherent and atomic manner, the network connections.

Management issues of new IP based equipment have driven a further evolution of the informative model of the product including the participation to standardization process: TMF MTNM and TMF MTOSI are the most relevant standards.

*NE Specific Functional Plug-ins.* NetViewer proprietary model / standard model adaptation is performed by means of the Functional Element Manager [FEM] additional module, which is a component of the NetViewer Suite.

The plug-in oriented solution of NetViewer is retained in the FEM; it is composed by a core data-driven engine, a number of NE specific plug-ins (well-defined XML document set) and a RMI / JMS based north bound interface. Each NE specific plug-in provide the functional model extension.

NetViewer Suite connectors towards NMSs (or other OSSs) exchange information with NetViewer core by means of FEM and its functional plug-in.

NetViewer does not need further information other than the MIB definition of the specific NE in order to provide Inventory, FM and PM management on single NE base. The only correlation supported is the relation between faults, measurements and configuration and the NE. TMF MTNM and 3GPP models foresees more complex relations and object hierarchy. Ports, Cross-Connection, Measurement Points, Link, Trails and other are key objects in such models. FEM adapts the simple physical model of NetViewer in the target logical one.

## 2.9 Positioning and interfaces

NetViewer often acts in a multi-actors scenario: in many case the NetViewer system is not installed as stand-alone, but it is integrated in other Operations Systems and Software [OSSs], either standard or proprietary. In this scenario NetViewer plays the role of a mediation device between the Siemens microwave NEs and the higher level OSS (see Fig. 3).

*North-bound interfaces.* The following north-bound interfaces are provided with the NetViewer Suite:

- SNMP Agent, a real-time northbound interface implementing the SNMP over UDP/IP
- TCOA (TMF CORBA Agent), a real-time northbound interface implementing the TMF MTNM 814 V2.1 CORBA Solution Set;
- TNMS Core - NetViewer Connector, a TCOA customized northbound interface enabling the integration of NetViewer in TNMS Core, the Siemens Network Manager for Transport Networks;
- Radio Commander - NetViewer Connector, a set of products that allow the integration of NetViewer in Radio Commander, the Siemens Element Manager for Radio Access Networks;



- SPOTS - NetViewer Connector, a suitable interface (based on XML File Transfer) that allows SPOTS to manage MW Performance Measurements (ITU-T and ETSI) and relevant post-processing. SPOTS is a Siemens' product;

All of these interfaces gain advantage from the common information model.

The adaptation layer is developed using the J2EE technology. The open source J2EE application server JBoss was chosen as framework because it is open source product and there is a development community that provides support, share knowledge and manage a bug repository.

*Application server JBoss.* There are a number of reasons behind the use of an Application Server:

- J2EE is emerging as a middleware to cut development costs
- J2EE is emerging as a standard in order to achieve independence of applications from operating systems, DBMS, protocol stacks etc.
- J2EE is emerging as a middleware to simplify interoperability between software applications, having been originated in the EAI (Enterprise Application Integration) application framework. For such reason, it is an optimal starting base for the development of Open Interfaces.

### 3 FURTHER DEVELOPMENTS

#### 3.1 Post-processing capabilities

Extension of post processing capabilities on collected data are foreseen, in order to provide better maintenance tools based on performance statistics. In this direction, the reporting services of SQL Server product are under study; the analysis is evaluating the advantages provided by this environment, concerning task design, post-processing of stored data, reporting facilities.

#### 3.2 Web services and Service Oriented Architecture [SOA]

Current NetViewer Suite implementation is oriented to tightly coupled NMS – EMS interactions; SNMP Agent [SMI and MIB], TMF MTNM Agent [Specific V2.1 IDLs, Naming and Notification Services], OSS/J Agent (QoS PM API) are RMI/JMS based. Due to the strongly typed interface used, OS, framework [i.e.: Vendor ORB] and implementation languages constitute the main issues to take into account.

OSS/J and TMF MTOSI introduce the XVT concept [XML Value Type]; well-defined documents and content format make possible to decouple the EMS and NMS applications. Next step to gain a loosely coupled pattern is to integrate the Web Services

technology in the management system using SOAP protocol.

Integration activities at the customer premises and product development and deploy will gain great benefits from this solution.

#### 3.3 Compliance to new standards

NetViewer integration in OSSs compliant with well-specified standards and customer requests of compliance are the main drivers to introduce the emerging standards solution (i.e.: MTOSI) in the microwave management system.

### BIOGRAPHY

#### Marco Alberti

He was born in Milan in 1969 and was graduated in Electronic Engineering in 1996 (Milan University). He works for Siemens since 1996 and is responsible for a TMN SW Development team in the R&D area. He is in charge of Design, Development and Integration activities of additional north bound modules in the NetViewer Suite.



#### Massimo Bernini

He was born in 1967 and was graduated in Electronic Engineering in 1993 at Pavia University. In 1995 he joined the R&D department of Siemens Networks S.p.A. where currently is in charge of the architecture

and the development of NetViewer core System.



#### Michele Frassetto

He was born in 1973 and was graduated in Telecommunication Engineering in 1999 at Padua University; he is a Siemens Networks employee since 2000. He is senior software architect of NetViewer core system.